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ABSTRACT

Using reading models interchangeably with reading theories blurs the distinction between models as representations and theories as explanations. This report presents several models of reading comprehension and compares the functional purposes and research implications of selecting one model over another. The report draws the following conclusions: The serial processing versus parallel processing issue has emerged as a salient feature in the models presented, but, since this distinction has not been demonstrated to be meaningful or testable, it seems necessary to de-emphasize the issue in future models. Any model that assumes hierarchical processes should have impeccable evidence demonstrating the need for such an assumption. Although interactive models are more flexible than independent stage models, they need to be made more precise and more limited. Models should be fully grounded in data, and care should be taken in the construction and evaluation of models. Although much effort has been expended in modeling the reading process, what is needed now is more emphasis on theory. (Author/RL)

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ALTERNATIVE MODELS IN READING COMPREHENSION

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The most important task in comparing alternative models of reading is to focus clearly on what a model does or is supposed to do. In the past few years, models in reading seem to have become an end in themselves. Just the other day I was given some poster boards with a variety of unlabelled squares, circles, arrows, lines and rhombuses on them. Attached to this collection was a sign which read "which of the following represents a model of reading?" The correct answer was not specified.

Philosophers of science have made careful distinctions between the notions of models and theories. Typically, a model is a part of or adjunct to a theory. Lachman (1960) has distinguished four roles for models:

1) Representational - this function generally provides a means for talking about or conceiving the basic data (and inter-relationships) that underly the model. It is important here to remember that this is an analogical usage. The models are not believed to be direct representations, but they are to be taken as <u>similar</u> representations.

2) Inferential - Lachman states that the rules by which predictions are made from a theory are another function of models. The most common type of inferential model is the mathematical model. The rules of inference used in the original domain from which the model is taken are to be used in the new context. For mathematical models, the rules of inference are the rules of mathematics calculus, and logic.

3) Interpretational - theoretical terms and definition must be linked to observational data. Models often serve this function by showing how to apply the theory. A theory may be explained and tested in terms of the model.

4) Visualization - Lachman indicates this may be the most common of modular functions. A familiar example is that of atomic elements consisting of nuclei and particles orbiting around them. In psychology, the "lavatory cistern" model of Broadbent (1958) to account for attention processes fulfills this visualizing function rather graphically in Figure 1.

What is most salient about the four functions Lachman lists is that they do not involve explanation - a task which is reserved for theories. Theories are testable; models are not subject to verification. It is also important to note that there may be many models that can be applied to the same theory or set of data (Cohen and Nagel, 1953). To help evaluate alternative models, Lachman lists three criteria:

1) Deployability - Can the model be brought to bear on the theoretical phenomena?

2) Scope - Does the model cover all the theoretical phenomena?

3) Precision - Is the model specific with regard to the theoretical phenomena?

A fourth criterion should be added; it is usually known as Occam's Razor. That is, a simpler model is to be preferred, all things being equal.

With this brief discussion in mind, it should not be surprising that there are a profusion of models that have been applied to reading. Most models in reading are interchangeable with "theories". It is not crucial, but such usage does blur an important distinction: representation versus explanation.

The remainder of this paper is intended to deal with a number of models, their functional purposes and the research implications of selecting one model over another.

The phrenology model - Phrenological theory holds that human traits or faculties are divided into two major classes, affective and intellectual. The major classes are subdivided into specific faculties which are localized in the brain.

Localizations are modelled on the assumptions that external bumps or protrusions correspond to increased faculties. Note that the theory specifies separate faculties and brain localization. The model specifies the way in which the faculties can be identified and localized. An additional model specifies the nature of identifying individual faculties - that is, correlational observations are accepted as basic data. (Traits in individuals are correlated with protrusions. General patterns were then identified.)

It is unlikely that Gall and Spurzheim dealt with the specific problem of modelling the reading process. It is just as well. If we believe in remedial training, the phrenological "model" might dictate the use of appropriate blows to the head to increase certain faculties. This model may not pass the criterion of "scope". It accounts for the basic faculties in reading, but not for their remediation.

In terms of research implications, the phrenological model limits the methods that may be used ethically. Short of brain surgery, the only methods that can be used are correlational. Moreover, the questions that may be asked involve the faculties that can be isolated. However, this is unfair, for the phrenologists probably did not intend for their model to apply to the reading process except incidentally. As an example, though it shows that not every model is useful for reading.

Some current models of reading illustrate the research implications of choosing alternative models:

Gough's Model (1972)

Gough proposed a serial model with a set of linear, independent stages of processing. Gough does not propose a theory as such, but provides the visualization of the model given in Fig. 2. As a model, this proposal is a visualization as well as an interpretation of the reading process.

For Gough's model, reading proceeds letter-by-letter to word formation and then to phonemic representations. Lexical meanings are grouped into sentential units and interpreted by "Merlin", the "magical" processor of syntactic and sematic information. Sentences are sent to a place called TPWSGWTAU (the place where sentences go when they are understood.

Most of Gough's discussion focusses on word recognition and then lexical interpretation. Higher level comprehension processes are not discussed, primarily because they are not sharply defined outside of the

reading process. Gough specifically rejects the notion of "top down" processing. His model is almost prototypic of the "bottom-up" variety. That is, Gough does not believe that readers use guessing strategies to facilitate reading.

There are then no immediate implications for comprehension research in reading. What must be done is to investigate both the MERLIN process and the TPWSGWTAU storage. When they are better understood, they can be incorporated into on-going research.

Applying the evaluation criteria to Gough's model, it seems to be deployable and of broad enough scope - although it seems applicable only for skilled readers. The early processing stages are quite precise, while comprehension stages are not.

LaBerge and Samuels Model (1974)

This model is the first of the models to use the concept of automaticity. (It should be noted that LaBerge and Samuels write about a theory of automaticity, not a model.) Automaticity theory assumes that reading is divided into two general skills: Decoding and comprehension.

It is further assumed that attention is required to perform either skill. Moreover, only a fixed amount of attention is available for these processes. Until decoding is "automated" (i.e., until it requires very little or no attention) comprehension suffers. As decoding comes to require less attention, the extra attention can be diverted to comprehension.

A representation of the model is given in Fig. 3. There are three stages that are strictly relevant to reading: 1) Visual feature detectors

and recognizers, 2) phonological interperters, and 3) semantic interpreters. In each stage, units are processed singley or in groups.

Some stages can be by-passed. For example, word patterns do not have to be phonologically interpreted in order to be assigned meanings. Such meanings might be assigned from episodic memory.

Again, this is really a "bottom-up" model. It assumes that all reading must be initiated by a visual input and terminated by a semantic interpretation. As Rumelhart (1976) has pointed out, it is not as strict an example as Gough's model. The by-passing of some stages does not make it a fully serial processing model. However, it is not a model which has "top-down" capabilities.

What implications are there in this model for research in comprehension? First, an obvious manipulation is to vary level of ability to decode. Comprehension should vary directly with the ability. Second, episodic cues should facilitate semantic interpretation. However, semantic interpretation should not have any effect on visual feature identification. (Note that these predictions blur the model-theory distinction discussed earlier.)

How does the model fair when evaluated by the criteria given earlier? The model is deployable, except for the top-down processing capabilities of competent readers. It is of sufficient scope, but it falls short on precision when it deals with attention allocation and rules for by-passing processing stages.

Goodman's Model (1968)

This model is included only as a comparison. It consists of three "proficiency levels", corresponding to skill levels of the readers. At the highest level of proficiency, Goodman claims that the focus is always an meaning, that decoding is automatic, and that reading is structured by oral language. A representation of each of the three levels is given in Fig. 4.

In this extreme form, Goodman's model is almost a strict "top-down" process. There is almost no cue usage from the graphic input.

Applying the criteria, Goodman's model passes the tests of deployability and scope. It fails clearly on the criterion of precision. And finally, the usefulness of the model is limited in that it is relatively powerful - almost any finding can be accounted for in the model. That is, since oral language is the basis for meaning in reading, errors in reading can almost always be interpreted as "miscues" rather than mistakes.

Rumelhart's Model (1976)

Rumelhart has generated a computer model based on what he calls interactive stages. The schematic representation is given in Fig. 5. What is unique about Rumelhart's model is its provision for top-down as well as bottom-up processing. Thus, the model predicts that a reader can begin with graphemic input to guide the extraction of meaning. Alternatively the reader can assume features and proceed with meaning (hypotheses) first, moving to verification of features and word patterns later.

Five implications of the model are given by Rumelhart (1976). (However, Rumelhart suggests these are the foundation of the model, not the implications of it.)

1) Perception of letters often depend on the surrounding letters.
2) Perception of words depend on the syntactic enviroments in which they are encountered.
3) Perception of words depend on the semantic enviroments in which they are encountered.
4) Perception of syntax depend on semantic context in which word strings are encountered.
5) Interpretation of meaning of what is read depends on the general context in which the text is encountered.

Given these implications, it should be noted that little emphasis is placed on word recognition. Almost all information processing is assumed to be done in parallel. This model is attractive in that it is more flexible than the others presented. It has generated greater interest in comprehension than the others.

How does Rumelhart's model fair when evaluated by Lachman's criteria? The model seems emminently deployable and of sufficient scope. It does seem to suffer in precision and in the general notion of usefulness. The model is almost too powerful - it seems to be able to deal with any experimental result. (This is reminiscent of Chomsky's arguments against the generative semanticists position.) That is, there appear to be no boundary conditions to the model.

Conclusions

Several issues seem to emerge when alternative models of reading and comprehension are compared:

1) are various stages of information processing arranged serially or in parallel?

2) Are the processing stages heirarchical or linear?

3) Are the stages of processing independent or interactive?

The serial versus parallel processing issue seems to have emerged as a salient feature in the models presented. Townsend (1974) has demonstrated convincingly that this is not a meaningful or testable distinction. He has shown that any serial process can also be modelled by a parallel process. Thus, it would seem necessary to de-emphasize this issue in future models. The added power of parallel processes would give them the edge.

Heirarchical processes are easy to verify. No higher level process can be performed without all of the lower level processes. This is essentially an empirical rather than a theoretical (or modular) question. Any model that assumes heirarchical processes should have impeccable evidence demonstrating the need for such an assumption.

Interactive models do have the advantage of being more flexible than independent stage models. Interactive models are attractive for their feedback capabilities and seem to have a high degree of ecological validity (Bronfenbrenner, 1976). However, it seems that interactive models need to be made more precise and have some boundary limits placed on them.

Models should be fully grounded in data. There are techniques for determining how various stages should be related to each other (Sternberg, 1969). Great care should be taken in model construction and the subsequent evaluations of them. The tools are available. When a model is constructed or chosen, it will help dictate the answers to the following questions:

1) What problems should be the subject of research investigations?
2) Which problems should be investigated first?
3) What independent variables should be manipulated?
4) What dependent variables are acceptable (or relevant) to the research problems?

Much effort has been expended in modelling the reading process (Singer and Ruddell, 1971; Singer and Ruddell, 1976; and Davis, 1971) What is needed now is more emphasis on theory - the reading process must be explained as well as modelled. It is important to look for relationships that may exist among models and theories. Since most models purport to relate to the same phenomenon, they may have much in common.

Almost all comprehension processes need to be researched and clarified. They will play key roles in future reading models. Choices among lines of research dictated by present models will ultimately affect those future models. Presently, we have neither a single best model nor a single best theory. Synthesis will be required to succeed in generating either or both.

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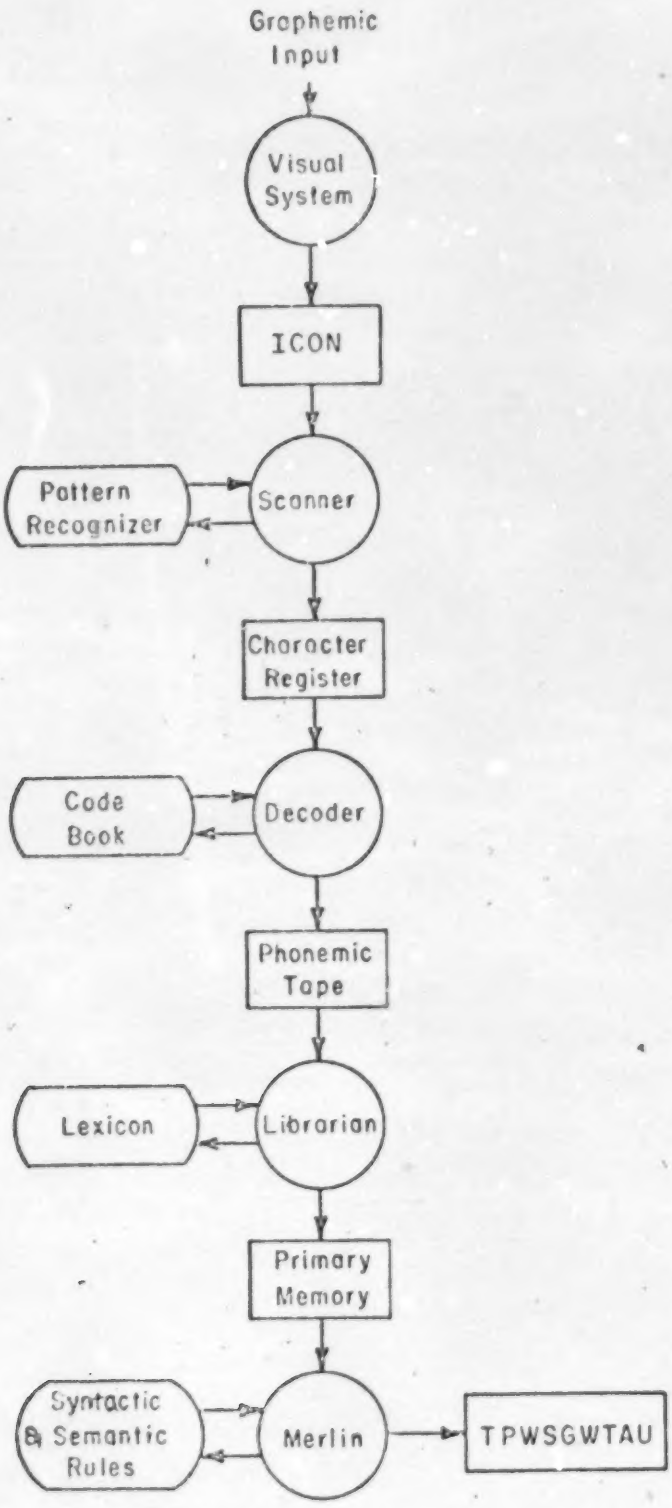


Figure 2 Gough's Model (1972)

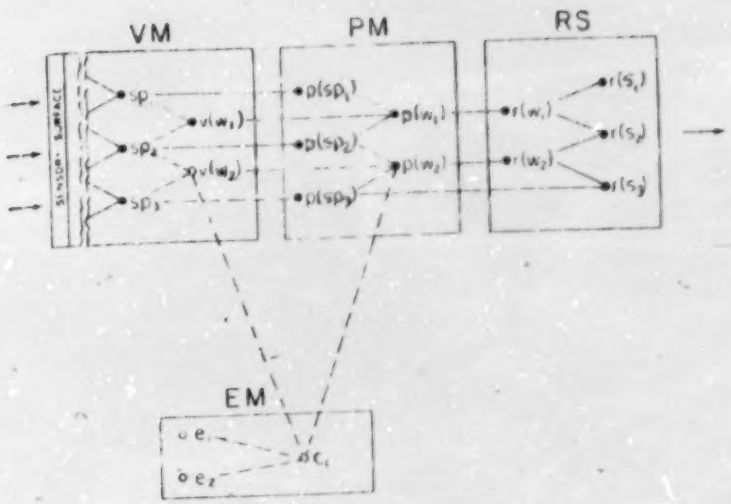
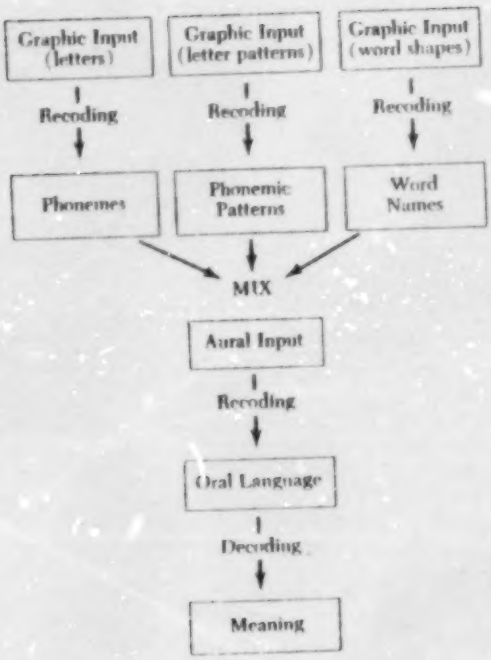
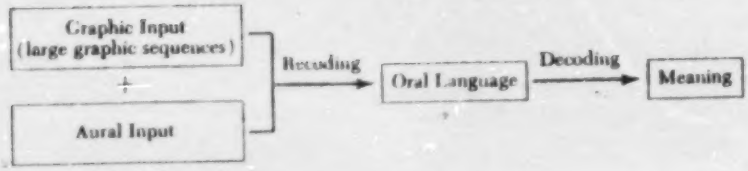


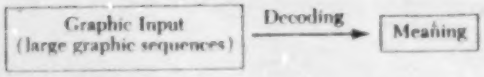
Figure 3 LaBerge and Samuels' Model (1974)



Proficiency Level 1



Proficiency Level 2



Proficiency Level 3

Figure 4 Goodman's Model

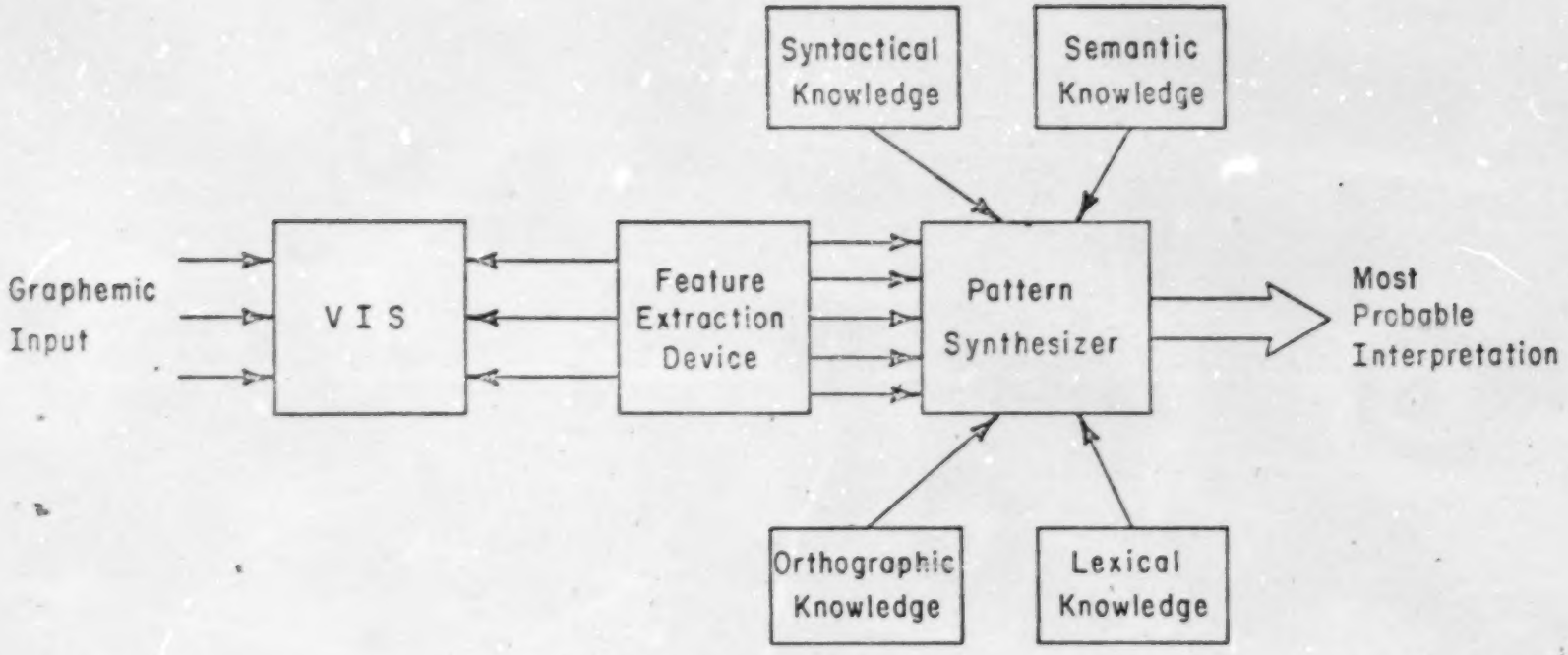


Figure 5 Rumelhart's Model